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Developing an Overall Framework for Evaluating and Communicating the Impacts of Capital Spending to Central Agencies

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Developing an Overall Framework for Evaluating and Communicating the Impacts of Capital Spending to Central Agencies

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Abstract:	Decision-making related to transportation system development requires an effective mechanism to translate the impacts of transportation investments into measures corresponding to major socio-economic objectives of the government. In order to match transportation initiatives with broader socio-economic objectives, many transportation agencies usually base their decisions on an evaluation of key summary impact measures of investments such as a cost-benefit ratio. However, more specific indicators of transportation investments are often required by particular levels of the decision-making hierarchy. This report describes the development of a comprehensive system of indicators which would allow the impacts of transportation investments to be appropriately translated and effectively communicated to each level of the decision-making hierarchy. This is achieved through the development of methods to evaluate specific socio-economic impact indicators of transportation investments such as consumer benefits, business competitiveness, accessibility to government services, and so on. These socio-economic indicators are the main elements of an effective communication system. The final section of the report contains a proposal describing a prototype system which will provide indicators to assess the impacts of transportation projects on regional development and economic growth in Ontario.
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1/ Introduction

1.1/ The Communication Problem

The Ontario Ministry of Transportation's mandate, as defined in *Strategic Directions 1988*, is

> To be the provincial leader in transportation and provide the focal point for the identification of the transportation needs of the people of Ontario.

Further, the Ministry provides information relating Ontario's transportation needs to the provincial government's central objectives. *Strategic Directions 1988* states that it is the Ministry's responsibility

> To maintain effective two-way communications with the public to ensure that the transportation expectations and aspirations of various segments of Ontario society are identified and reconciled within the framework of government policies and programs. [1]

The problems encountered in achieving this task have been identified by Mouaket and Lucey [2]. Essentially, they state, there is an absence of transformation mechanisms to convert the existing data into relevant information for political or senior management, creating a communication barrier between technical and political or senior management staff.

Improvements need to be made to the existing communication system to overcome these difficulties. First, the communication system must develop a common terminology which can be understood and be meaningful to both lower and upper levels within the governmental management hierarchy. While no single set of terms can satisfy all the needs for communication between various levels in the hierarchy, levels which actively interact, such as technical staff and senior management, need a common language. Second, the communication system must embody mechanisms to translate terminology and concerns which are appropriate at one level of the decision hierarchy into terminology and concerns which are appropriate at other levels. Pavement condition ratings of highways (PCR's) can be used to illustrate this point. PCR's represent a technical concept and measurement which is meaningful at the technical staff level. Senior administrators and politicians, however, would find the fleet maintenance costs which are associated with pavement condition more meaningful. It would, therefore, be desirable for technical staff to translate PCR's into the associated fleet maintenance costs when communicating with senior administrators and politicians.

Indicators of the primary and secondary impacts of transportation investments provide a basis for the common terminology described above and can play a major role in an improved communication system.

1.2/ The Potential Role of Indicators of the Primary Impacts of Transportation Investments in Improving Communications

The TRIM system (Transportation Impact Model), as did its predecessor, MEIS, provides indicators of the impacts of spending associated with the construction phase of capital projects on sales, income, employment, taxes, imports and energy use (termed secondary impacts). These indicators are required and have proven useful in communicating the impacts of capital spending to senior management of the Ministry and at higher levels of the Ontario government. However, they represent only one element of the total impact of a transportation project. The transportation improvements decrease the cost of transportation to businesses and the public, facilitating and directing the development of Ontario's economy. These impacts on the transportation system users' are called primary impacts. Improvements are needed in the Ministry's ability to evaluate and communicate the primary impacts of its activities. This need can be satisfied by the improvement and expansion of the systems currently used within the Ministry. The development of a system which would operate parallel to TRIM and provide indicators of the primary impacts of transportation improvements is recommended.

There are a wide variety of indicators of the primary impacts of transportation improvements. These are described in detail in a companion report, "Indicators of the Primary Impacts of Transportation Improvements." These indicators can be grouped and arranged into a hierarchy which parallels the hierarchy of decision-making within the Ministry. Some indicators, such as travel times or PCR's, are technical measures which are meaningful primarily at the technical staff level. Other indicators, such as changes in fleet operating costs or developmental impacts, refer to socio-economic effects and are more meaningful at the senior administrative and political levels underlining the fact that different groups of indicators are required for the communication of impacts at different levels in the decision-making hierarchy.

The indicators of primary impacts currently used within the Ministry are those appropriate at the technical staff level. There is very little use, if any, of indicators of primary impacts which relate directly to the socio-economic concerns of political decision-makers. A communication problem, therefore, exists and relevant information is not being supplied to political decision-makers. This

report recommends that systems which will create these indicators and close the information gap be developed.

1.3/ Structure of the Report

Section 2 examines the potential role which indicators of the primary impacts of transportation investments can play in improving the ability of the Ministry to communicate the impacts of its activities. In this section, the governmental decision-making structure (the communication system) is described and the flow of information within this structure is discussed. Subsequently, a hierarchy of indicators of the primary impacts of transportation investments is presented and "matched" to the communication flow. A major weakness of the present communication system is an absence of a group of indicators called "specific impact measures," which includes indicators of impacts on socio-economic factors such as regional development, business costs and competitiveness or the accessibility to government services. This group of indicators is especially useful in communicating the impacts of transportation investments to senior administrators and politicians.

Section 3 of the report presents a research programme aimed at establishing a system capable of providing a full range of indicators of the primary impacts of transportation investments. The plan presented is only one possible approach and its content and timing can easily be modified. One recommendation, however, at the initial stage of the research is that one or more of the "specific impact measures" be developed, such as indicators of business competitiveness or regional development. The Ministry can then assess the usefulness of these specific impact indicators at the earliest possible stage in the research programme.

In Section 3, a system which will produce primary impact indicators is presented as a group of modules each responsible for production of a specific indicator. The input data which are required and link to other modules are identified. The development of a module or related sets of modules is identified as a project, and these projects are structured in such a way that all required modules are included. For example, to provide indicators of the impacts on business and regional development two separate modules will be developed. However, the regional development module would use indicators of impacts on business (the output of the business module) as a part of its input data. The construction of these particular modules is treated as two separate projects in section 3 but, potentially, could be accomplished in one larger project. One possible schedule showing the timing of the projects is suggested and estimated costs are presented.

Section 4 is a proposal for one project which is a candidate for the initial phase of the research programme; namely, construction of the regional development module (proposals for other projects are included in the report to MTO). The proposal contains a detailed discussion of potential impacts of transportation investments on regional development, a discussion of methods of identifying these impacts, a proposed methodology, an identification of data requirements and an estimated budget.

Section 5 contains a summary of the main arguments of the report, together with its major conclusions and recommendations.

References:

[1] MTO, *Strategic Directions 1988*.

[2] Mouaket, Ibrahim M. and James F. Lucey, "Communicating for Results in Managing Pavements in Ontario", *Proceedings of the Second North American Conference on Managing Pavements*, November 2-6, 1987, Toronto, Volume 3, pp. 131-146.

2/ The Role of Indicators of the Primary Impacts of Transportation Improvements in Communicating the Impacts of Transportation Investments

This part of the report examines the role played by indicators of primary socio-economic impacts of transportation investments in the communication processes associated with resource allocation decisions of the Ministry of Transportation and the government of Ontario.

2.1/ Introduction

An investment in a transportation facility produces a range of primary and secondary socio-economic impacts. This study looks only at primary impacts, which refer to the benefits derived from the use of a new or upgraded facility and to the effects of these improved services on both users and non-users of the transportation system. Secondary impacts describe the economic effects of the capital expenditure or construction phase of the investment and were addressed in a previous study, which led to the development of the TRIM system.

This section examines the role indicators of the primary impacts of transportation investments can and should play in communicating these impacts to central agencies. The discussion focuses on those aspects of the communications system that relate to budgetary allocation, both by the Ministry and by Cabinet. In order to clarify the function of primary impact indicators within the communication system, it is necessary to analyze the role of the communication system in the context of the decision structure of government, particularly as it relates to transportation investment decisions.

A conceptual framework describing the structure of the decision process within the Ministry and the Provincial government and the information system supporting this decision making structure is developed in this section. This framework reflects the information collected through a series of informal interviews with senior management of MTO in which the decision making structure and lines of communication were discussed.

It should be understood, however, that the government communication and decision framework postulated below is not intended to account with exact precision and detail for the structure of Ontario governmental processes in general or those of MTO in particular. It is conceived rather as a

pragmatic representation of the actual communication/decision system most pertinent to the use of indicators in communicating the impacts of transportation investments.

This conception provides a relevant framework for the discussion because the objective of this study is to provide information and advice on the use of indicators. The study is not intended to provide either an evaluation of or advice on the Ontario governmental decision structure itself.

As depicted in Figure 2.1, the conceptual structure assumed for this discussion of the decision-making system is defined by:

1) a series of levels in a decision-making system;
2) the flows of information between these levels; and
3) the interactions between levels that produce and transmit this information.

Four basic levels are identified in Figure 2.1:

1) the government or political level (Cabinet, Management Board);
2) the senior Ministry management level (Deputy Minister, ADM's, executive directors);
3) the technical management level (managers, directors); and
4) the operations level (district/regional staff).

It should be noted that no effort has been made here to distinguish between potential overlapping structures of decision-making between MTO head office branches and regional and/or district headquarters.

The nature of the input information about primary socio-economic impacts which flows between levels in the system is the matter of central concern in this study. These flows of basic input information are identified on the left side of Figure 2.1 and are made up of two major components. The downward flows (first column) relate to institutional goals and broad policy objectives established at the government level. Typically, these objectives are translated by senior Ministry management into appropriate organizational objectives, and directed to the technical management teams of the Ministry. The organizational objectives are subsequently framed in terms of explicit operational objectives and passed directly to the operations level.

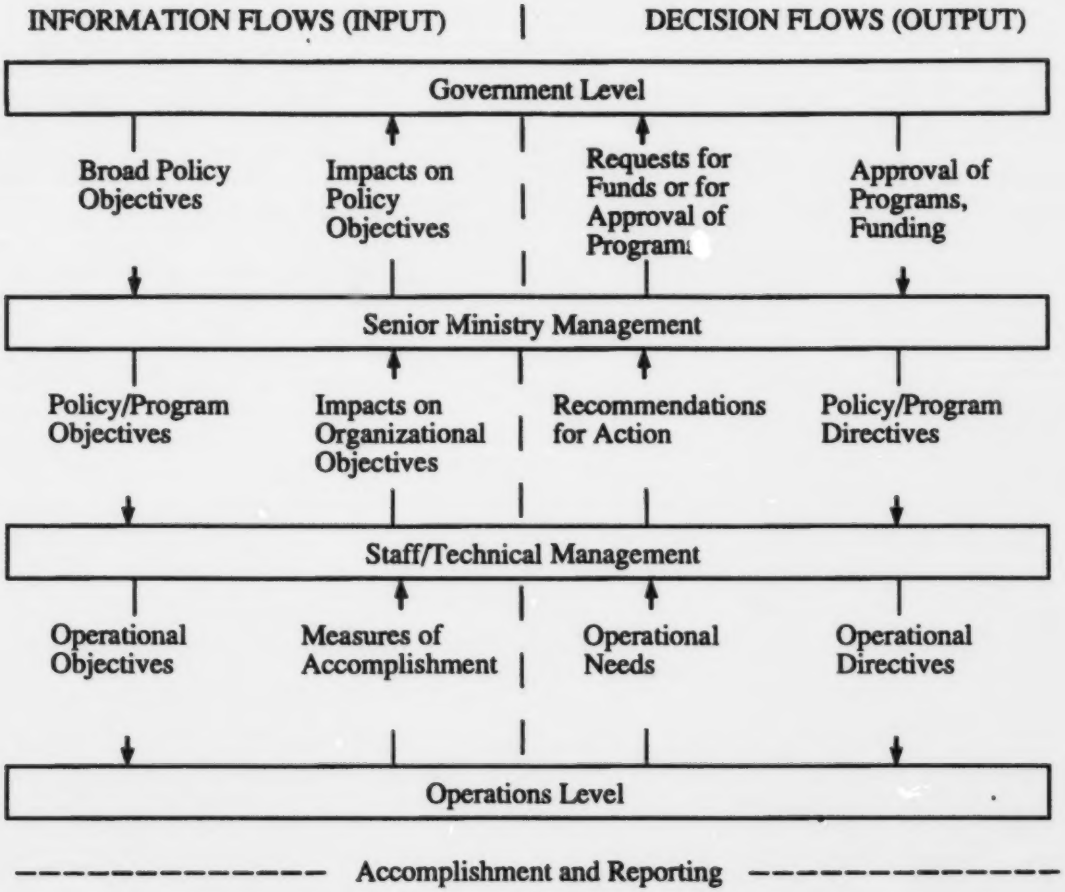

Figure 2.1/ Conceptual structure of the information and decision-making process

The upward flow of information relates the results of the Ministry to the decision-makers (second column in Figure 2.1). Measures of accomplishment, impacts on organizational objectives and impacts on policy objectives of the Ministry's actions flow upward from the operations level to the political level.

Intuitively, then, the information flows shown on the left side of the figure represent information required to facilitate the decision-making process. Obviously, it follows that indicators of the primary impacts of transportation investments are a part of the upward-flowing information.

The right side of Figure 2.1 represents the decision-making process itself. Two major components of this process are identified. The flows moving upward from the operations level (third column) represent operational needs, subsequent recommendations for action from the technical management

level, and corresponding requests for program approvals made to the political level by senior Ministry management. The second aspect of decision-making involves the downward flows (last column) of actual program approval and funding by government, program directives from senior management, followed by operational directives to the operations level from technical staff.

The information flows on the left side of Figure 2.1 (the communications system) provide support for the decisions represented on the right side (the decision system). In order to be most useful, the information which flows between two adjacent levels in the decision-making hierarchy should be easily understood and considered meaningful by both interacting levels.

The conceptual framework of the information and decision flow depicted in figure 2.1 is used to discuss the role of primary impact indicators of transportation investment. It is demonstrated that they should play an important role in the upward flow of information as shown in the second column of Figure 2.1. They should provide meaningful, representative and, ultimately, intuitively appealing input to the decision-making process.

To help understand the potential role of indicators of primary impacts within the communication system, these indicators were classified according to the type of information which they convey. They were then arranged into a hierarchy which roughly corresponds to the order in which they must be constructed. This hierarchy will then be related to the decision-making structure in order to indicate clearly the role which these indicators can play.

The suggested hierarchy is shown in Figure 2.2, where four basic types of indicators are included:

1) transportation system characteristics;
2) direct user benefits;
3) specific impact measures; and
4) summary impact measures.

These are ordered in a logical sequence. Transportation system characteristics comprise the basic data. They determine direct user benefits (levels of service), which in turn impact specific groups in the economy. These specific impacts can be combined into summary measures of impact.

I Transportation System Characteristics	II Direct User Benefits	III Specific Impact Measures	IV Summary Impact Measures
* capacity * condition	* travel time * safety * reliability * maintenance cost * operating cost	**Business** * profitability * economic development * land use **Consumer** * transportation costs * quality of life **Society** * accessibility * government services **Government** * costs of providing services * taxes and budget	* net present value * cost-benefit ratios * land values
Transportation Engineers and Planners		Political and Administrative	Economists, Transportation Engineers and Planners

Figure 2.2/ A hierarchy of indicator measures

Interestingly, one is immediately tempted to relate each of these indicator types to a particular level of decision-making identified in Figure 2.1. The transportation system characteristics, for example, may be associated with the operations level; the direct user benefits are most meaningful to technical staff; and the specific impact measures to the senior administrative and government levels of decision-making.

Summary impact measures play a somewhat different role than the other types of indicators. They combine many impacts into a single measure, and are not conducive to intuitive understanding and, as a result, are less useful for communication than the specific impact measures. They are useful for prioritizing projects or programmes and are used for this purpose at the technical staff level. When they are used in this way, they are a part of the technical information which flows horizontally within this level of the decision-making structure (Horizontal flows of information are discussed in section 2.3).

The sections which follow provide much more detail on the rationale for the concepts depicted in Figures 2.1 and 2.2. In essence, the following sections document our attempt to connect two separate streams of literature: the public policy literature on communication within decision-making structures; and the transportation planning literature on indicators of the socio-economic impacts of transportation investments. Although the discussion is carried out in general terms, illustrations are based on our understanding of MTO.

2.2/ The Decision Process

For purposes of this discussion the governmental decision-making structure is assumed to contain four distinguishable levels of responsibility shown in Figure 2.1.

At the "top" of the decision-making hierarchy are the political decision-makers. The next level of responsibility is senior management within a governmental agency. For the sake of concreteness, the typical government agency referred to in this discussion will be the Ministry of Transportation (MTO). The responsibility of these two levels of decision-making will be discussed in detail in Section 2.2. Next is the staff or technical management level, which is responsible for operational planning, monitoring of activities and recommendations to senior management concerning programs and activities. Finally, there is the operations level, which is responsible for carrying out operational directives and for reporting needs and accomplishments to the technical staff level.

2.2.1/ The Interface Between Government and Senior Management

Government policy decisions are ultimately made by Ministers working together as a Cabinet. The Cabinet develops the broad objectives of the government, which follow the governing party's political aspirations, and sets the general and more immediate priorities for these objectives. The last task follows from the natural budgetary constraints and the necessary tradeoffs involved in budgetary decisions.

Ministers of the Cabinet must then communicate broad policy objectives and priorities to senior administrators in the various ministries. The senior management level responds to these objectives and priorities by organizing programs, requesting funding for them and reporting back to the political level on the accomplishment of Ministry activities. As part of this process, compatibility between Ministry activities and the objectives of government can be sought through tight budgetary control.

The importance of the information flows at the government-senior management interface cannot be overstated. The success of specific programs in meeting stated political objectives is to a great extent determined by the nature and intensity of the interaction between the political and administrative branches of government. In this context, information flows which support this interaction must link the broad objectives of government (e.g., business competitiveness) and the accomplishments of various agencies (e.g., highway construction). The burden of establishing this linkage rests primarily on the senior management level, which must determine how specific programs relate to broad policy objectives established by government. This key link is necessary both for planning and setting priorities for activities and for communicating to the political level the contribution of these activities toward meeting government policy objectives.

Indicators of the socio-economic impacts of transportation investments are an important part of the communication link between the senior management and political levels of government. In order to be most useful, these indicators must be clearly related to the broad objectives of government. They must also be easily interpreted and accepted by both the senior management and political levels, and very importantly, there must be a common understanding of their significance (see Holt (2)). Finally, they should be defined in a way that leads elected representatives to view them as providing useful (i.e., intuitively appealing and meaningful) information (see Kornai (3)).

2.2.2/ The Interface Between Senior Management and Technical Staff

At the next interface of the decision-making structure within a government agency is the interaction between senior management and technical staff levels (Figure 2.1). Senior management is responsible for establishing performance targets (organizational objectives) for the various programs

within an agency -- such as the level of highway system health as measured, for example, as the average system Pavement Condition Rating -- and for allocating funds to these programs (program directives). Technical staff must select projects for implementation within their program area (operational directives). They also must report the accomplishments of their program activities, such as completion of a new highway link, to senior management. The reported accomplishments should include impacts on users, such as reductions in congestion and travel times.

In order to develop the organizational objectives to carry out the program planning function within the senior management level (e.g., the allocation of funds across different transportation modes), the impact of various programs on broad governmental objectives should be defined. The same information base which is used to communicate the impacts of ministry activities to the government level should be used by senior managers for development of policy and program objectives and allocation of funds among programs.

The indicators that should be used at the senior management-technical staff interface are quite different from the indicators used between the top two levels of the structure. The management targets which would be useful at the technical staff level could not be stated in the broad socio-economic terms used at the previous level, but rather must be stated, for example, in terms of levels of service provided by the various Ministry programs (measures of levels of service could include travel times, traffic volumes or measures of capacity utilization). Useful communication across the senior management-technical staff interface requires translation between indicators of levels of service for the different transportation modes and indicators of the broad socio-economic impacts of achieving particular levels of service. Staff and senior management must therefore have available an information system that enables them to convert indicators of levels of service into indicators of socio-economic impact.

An additional complication in this part of the decision-making process arises because the levels of service in one transportation mode may be affected by the levels of service in another. Service levels provided by the entire transportation system must therefore be considered. It is also important that indicators of levels of service account for interactions between transportation modes so that intermodal impacts are reflected.

These intermodal impacts also necessitate communication between different program units within the same level of decision-making. For example, organizational goals such as the reduction of congestion in a particular corridor may be achieved by investments in several transportation modes, either singly or in combination. These modes may be represented by different administrative units

within both the senior management and technical staff levels. Both program planning at the senior management level and project planning at the technical staff level will require coordination of different administrative units at the same level.

A common system of service level indicators at the technical staff level and of socio-economic indicators at the senior management level will have much to contribute to this coordination. For example, reductions in travel time for goods movement and the resulting economic indicators provide a common basis for comparing and coordinating investments in rail transit and in highways.

2.2.3/ The Interaction Between the Technical Management and Operations Levels

The interaction between technical staff and operational personnel translates projects which have been chosen at the technical staff level into realized transportation infrastructure or services. The operational activity most commonly involves writing technical specifications for projects (design) and the selection (tender) and supervision of contractors (construction). It may also involve work by agency staff in activities such as highway maintenance.

An important aspect of this interaction is the generation of measures of system characteristics, such as highway capacities, condition ratings and indicators of levels of service, such as travel times, congestion and safety. These measures must provide the data necessary for the calculation of indicators of socio-economic impact needed at the higher levels of interaction.

2.3/ A Framework for Primary Impact Indicators

The preceding discussions have outlined the conceptual model of decision-making in government, with reference to decisions regarding transportation investments. The flows of information between the different levels within the structure which relate to indicators of the primary impacts of transportation investments have also been identified (Figure 2.1). In this section, indicators of these impacts are considered in more detail, referenced to the hierarchical framework introduced in Figure 2.2.

2.3.1/ An Overview

Indicators of the impacts of transportation investments are an important component of the upward, downward and horizontal flows of information within the governmental decision-making structure shown in Figure 2.1. Flowing upward, these measures provide a basis for assessing the desirability of various options at the political, senior management and technical staff levels. They also facilitate

downward flows of objectives, because they provide a basis for translating broader policy statements of goals into more specific guidance for action. Transmitted horizontally within a decision level, they allow comparison of investments in alternative transportation modes and between competing projects within a mode.

There are many types of indicators which can be developed to quantify primary impacts. These are described in some detail in the following sections. As suggested by Figure 2.2, they can be grouped into several broad categories according to the nature of the information that they convey:

1) transportation system characteristics;
2) direct user benefits;
3) specific impact measures; and
4) summary impact measures.

To assist in understanding this categorization, it is useful to recognize that transportation engineers and planners necessarily approach their work in terms of transportation system characteristics (e.g., highway capacities and conditions) and indicators of direct user benefits such as reduced travel time and improved safety. Summary impact indicators, such as net present values and cost-benefit ratios, are used in the process of planning at this level, and are calculated directly from measures of direct user benefits and used in project selection and programming.

Unfortunately, these technical measures are considerably less meaningful at the senior management and government levels than at the technical level. Decision-makers at the higher levels want measures that better reflect impacts of various projects on government goals, such as regional development, improved land use, or quality of life. As shown by the third category in Figure 2.2, indicators of this nature have been described as specific impact measures.

Collectively, these specific measures reflect the multi-dimensional nature of the impacts of transportation investments, something which is usually masked by a single summary indicator (e.g. cost-benefit ratio). Decision makers at the political and senior management levels may well find that a variety of specific impact measures convey a much clearer picture of the effectiveness of government activities than either technical measures of direct user benefits or summary impact measures. It is our view that the degree of success attained in establishing a communication system of the type suggested will be directly dependent upon the success of adequately defining and quantifying a selected set of specific impact measures.

The fundamental challenge, then, is to find meaningful methods for conversion of commonly used technical impact measures into specific impact measures that can be more easily and meaningfully interpreted at the government level. The sections which follow contain discussions which develop this notion in more detail.

2.3.2/ The Hierarchy of Indicators

The indicators presented in Figure 2.2 are arranged in a hierarchy according to the logical sequence in which they must be calculated. The flow of logic proceeds in the following manner:

1) System demands, system capacities and system conditions provide the fundamental description of the transportation system (system characteristics). For example, if we consider the highway system, demand refers to traffic flow, capacity to the ability to accommodate traffic flow and condition to the condition of the roadway. A particular transportation investment, such as an improved highway link, changes these system characteristics.

2) The increased capacity of the highway link in turn reduces congestion, improves travel times, safety and reliability (direct user benefits). These benefits to system users lead to lower transportation costs for business, households and government (further direct user benefits).

3) Lower transportation costs increase competitiveness and profits for business, leading to changes in land use and land values, and more economic development through induced investment. Households adjust their locations and transportation patterns in response to improved accessibility leading to further economic development. In addition, consumers may now spend money saved on transportation costs on other commodities. Lower transportation costs will also reduce the total cost of providing existing government services, improve accessibility to these services and allow government to expand services (within the same budget). These are all examples of specific impacts.

4) Summary indicators, such as cost-benefit ratios or net present values, are formed on the basis of direct user benefits and specific impacts. Summary impact measures are not, however, the best form of information for communicating impacts to senior management and political decision-makers. Their highly aggregate nature masks the multi-dimensional nature of impacts of transportation investments. Further, the non-technical staff of the senior management and government levels are often not familiar with the methodology and variables used in the construction of summary impact measures. As stated, these measures are used

for project prioritization and global assessment of investment decisions by technical staff and economists. However, indicators of the specific impacts which they summarize are more useful in communicating these impacts to senior management and political decision-makers.

In summary, the sequence which links the various measures discussed above provides a framework for translating changes in the transportation infrastructure into their effects on government objectives. The translation begins with technical measures of system characteristics, which are then translated into direct user benefits. These benefits are linked to specific groups in the economy such as business or consumers, and indicators of the various impacts on these groups are computed. Finally, these specific impact indicators are appropriately combined into broad summary measures.

It should be noted that this logical process does not mean that the whole sequence must be employed every time a capital project is to be analyzed. Rather, once the structure is recognized, it is possible to use individual measures for special purposes — their use depends on the context, complexity, or uniqueness of the analysis to be carried out. It is anticipated, however, that the sequence will be followed at least to the calculation of specific impact measures. To repeat, it is our view that a successful communication system must incorporate these specific impact indicators.

2.4/ The Structure of Indicators within the Communications Framework

This section defines why the different types of indicators are assigned to particular communication interfaces within the decision-making structure. The implications of this interface assignment for the generation and use of impact indicators within the Ministry are also shown.

2.4.1/ The Assignment of Indicators

While the description of the communication process proceeded from the political level down to the operational level, the discussion here builds from the bottom up, beginning at the operations/technical management interface. At this interface the most commonly used indicators are those which identify system characteristics and those which identify direct-user benefits.

Operational personnel deal directly with the transportation system and are naturally concerned with and aware of system characteristics. These characteristics are intertwined with direct user benefits and operational personnel are in a position to contribute to the identification of these direct user benefits. For example, the configuration and capacity of a highway link interacts with traffic demand and vehicle operating characteristics in determining travel time. Technical staff in communication with operational personnel identify and develop the methods of procedure to measure the direct user

benefit indicators. Operational personnel carry out systematic measurement of system characteristics, such as traffic volume, system capacity and travel time, and pass that information on to technical management.

At the next level of the communication structure, the technical management/senior management interface, indicators which describe both specific and summary impacts are the most relevant.

Technical management must convert their measures of direct user benefits into indicators of specific impacts which are more informative at higher levels in the structure. For example, the travel time indicator for a particular corridor might be converted into travel costs for business, households and government. Again, strong influence should come from the higher communicator in the interface — senior management can contribute to the selection and design of specific impact measures by identifying those impacts which are most closely related to political objectives (see Holt (2)).

Summary impact measures are also useful in this interface, since they provide support for system planning (project and programme selection). These measures are used to compare the impacts of alternative transportation investments and aid technical staff and senior managers in their setting of priorities, where a multiplicity of effects must be combined into a single ordering index.

The translation of specific impact measures into contributions to government objectives is obviously an important element of communication and decision-making at this highest interface of the communication system. Government goals tend to be expressed in very broad terms, but their implementation and the evaluation of accomplishment require a more concrete formulation. This formulation is the responsibility of senior management. While technical staff provide the specific impact measures which are most useful in identifying the contribution of transportation investments to government objectives, the selection of the indicators and final assessment of these contributions of investment to government objectives is carried out at the senior management/government interface.

For example, one broad political objective might be to improve business competitiveness. The specific impact measure which relates the effect of transportation investment on business competitiveness is business profitability, which can be calculated from direct user-benefits such as travel time, operating costs and reliability.

Indicator Types	Levels of the Decision Structure			
	Operating Personnel	Technical Management	Senior Management	Government
1. System Characteristics	M →	Gen		
2. Direct User Benefits	M →	Gen		
3. Specific Impact Indicators		Gen →	Use →	Use
4. Summary Impact Indicators		Gen, Use →	Use →	Use

Figure 2.3/ The role of indicator types within the communication system

The concepts inherent in the above discussion are summarized in Figure 2.3, which identifies the indicator type produced at each level in the structure and the communication of each indicator across the interfaces of the communication system previously identified in Figure 2.1.

The letters in the interior of the figure distinguish between the observation and measurement of basic data (M), the use of these indicators (Use), and the generation of impact indicators (Gen). Observation is usually associated with operating personnel, generation with technical staff and use of the indicators with senior management and political decision-makers. Horizontal arrows in the figure identify information flows across interfaces in the communication system which was shown in Figure 2.1. In particular, indicators of system characteristics and user benefits are transmitted only across the operating personnel/technical management interface (arrows at the upper left), while specific and summary impact measures are transmitted across the two higher level interfaces (arrows at the lower right).

Vertical arrows represent the translation of an indicator type into a higher type in accordance with the hierarchical sequence shown in Figure 2.2.

In the characterization shown in Figure 2.3, the system naturally divides into two parts. In the upper left is the operational/technical interface dealing with two types of indicators: system characteristics and direct user benefits. In the lower right is the senior management/political interface dealing with another pair of indicator types: specific and summary measures.

The two-part structure shown in Figure 2.3 identifies the conversion of indicators of direct user-benefits into specific impact measures as the crucial link between the two parts of the decision structure; namely, operating personnel and technical staff on the one hand and senior management and government decision-makers on the other. Without this conversion, the link between these levels would be broken and there would be a communications gap similar to the one identified by Mouaket and Lucey (4).

If specific impact measures are missing from the communications system, then it collapses to a system such as the one shown in Figure 2.4. In such a system, higher level decision-makers would have to depend on measures of system characteristics and direct user benefits and also on summary impact measures, all of which are difficult to relate to government objectives. Measures of both system characteristics and direct user benefits, as pointed out by Mouaket and Lucey (4), are based on technical concepts and expressed in technical terms which are very difficult to relate directly to broad government objectives (see Kornai (3)).

Indicator Types	Levels of the Decision Structure			
	Operating Personnel	Technical Management	Senior Management	Government
1. System Characteristics	M →	Gen →	Use →	Use
2. Direct User Benefits	M →	Gen →	Use →	Use
3. Summary Impact Indicators		Gen, Use →	Use →	Use

Figure 2.4/ A communication system without specific impact indicators

For example, using the technical measure of a system characteristic (Pavement Condition Ratings) for demonstrating the need for more expenditure on highway maintenance and rehabilitation to government decision-makers would fail. It is virtually impossible for government decision-makers to translate a decline in the average PCR into impacts on broad political goals, such as business competitiveness or economic growth, which govern the allocation of limited resources. The

intermediate steps of calculating the impacts of pavement conditions on transportation costs (a direct user benefit), and the impacts of transportation costs on business competitiveness and economic growth (specific impacts) are necessary in order to deliver the real significance of pavement conditions to senior management and political decision-makers.

Another example of improper usage of indicators is the use of a direct user benefit (travel time reduction) to justify highway expansion. Again, government decision-makers would experience difficulty in assessing the significance of travel time saving for goals, such as business competitiveness and economic growth, unless the intermediate impacts on transportation costs had been determined and subsequently translated into impacts on these goals.

The last case is the use of summary impact measures which provide a single indicator of a variety of impacts on a number of government goals. Because of their aggregate nature, these measures obscure the significance of the impacts of transportation improvements. For example, a benefit-cost ratio equal to two may be good (or bad), but it conveys little information about impacts on business competitiveness, economic growth, employment or consumers.

The present communication system within MTO is more like the system depicted in Figure 2.4 than the system depicted in Figure 2.3. As a result, it suffers from the kind of communications problems illustrated by the above examples.

When used by senior management, the specific impact indicators and summary impact indicators (Figure 2.3) serve two very different purposes: respectively, the prioritization of projects and programs associated with planning, and the communication of impacts to the government level.

The use of indicators for planning purposes involves comparisons across projects or programs. Summary measures are useful in this context because a single measure can be easily used to rank alternatives. The multi-dimensional nature of specific impact measures makes it more difficult to use them alone to rank projects. This multi-dimensionality is helpful, however, in relating the impacts of transportation investments to government goals, which themselves are multi-dimensional. This important aspect of specific impact measures is discussed in detail in the following section.

2.4.2/ Specific Impact Indicators and Political Objectives

In section 2.2.2 it is suggested that, in order to communicate the impacts of transportation investments to the political level effectively, indicators must be clearly related to broad government goals, be easily interpreted and be viewed as important by both senior management and political

decision-makers. Specific impact measures are designed to satisfy these criteria. Because of their multi-dimensional nature, particular indicators may be matched to particular objectives. In addition, these measures refer to concrete impacts and thus tend to be more meaningful to government decision-makers than summary measures such as net present value, which are aggregate and abstract. These latter measures are designed not as a communication tool but rather as criteria for final decisions. The specific impact measures are especially designed so a 'mapping' of them to the appropriate political objectives is possible. An example of such mapping is shown in Figure 2.5. Both political objectives and specific impact measures are arranged in groups. This grouping was possible because clusters of political objectives tend to be related to clusters of specific impacts.

Groups of Government Objectives

Groups of Specific Impact Measures	Economic: Short-Term	Economic: Long-Term	Social	Resources	Governmental
	Income	Overall growth	Standard of living	Environmental protection	Cost of programs
	Employment	Regional development	Housing	Energy conservation	Tax revenue
			Social services		Provision of services
			Other amenities		
			Social interactions		
Business					
Profit	X	X			X
Income	X	X			X
Employment					
Growth					
Induced Investment		X	X		X
Consumer					
Cost saving			X		
Resources					
Environment				X	
Energy use				X	
General					
Land-use		X	X		X
Land values		X	X		X
Accessibility		X	X		X

X = match between indicator and objective

Figure 2.5/ Mapping specific impact measures to government objectives

Four groupings of political objectives are identified in the top row of the figure: economic, social, resources and governmental. Economic objectives are divided into two sub-groups. Short-term objectives relate to improving the use of already existing economic capacity, with commensurate improvements in employment and income. Long-term economic objectives relate to increasing productive capacity, bringing about overall economic growth and/or regional development.

Social objectives are related to the quality of life of individuals. These include accessibility to employment, government services and other amenities, and availability of and cost of housing and reduction of noise pollution. All of these factors impinge upon the overall standard of living (or quality of life) of consumers.

Objectives related to resources include protection of the environment and conservation of energy. Examples of these goals are reductions in air and water pollution, and energy saving in transportation.

Governmental objectives refer to the impacts and management of the activities of government and, therefore, focus both on the provision of services and on the desire to avoid or reduce budgetary deficits. The provision of services is affected by accessibility to these services. Both the tax base and the cost of providing government services impact the government budget. The former is affected by growth of income and changes in land-use and land values, while the latter is affected by the transportation costs of government.

Specific impact indicators shown in the left column of Figure 2.5 are grouped into those relating to business, economic growth, consumers, resources and a general category referring to impacts related to combinations of these indicators. Business-related indicators include impacts on business profits, income and employment. Growth-related indicators measure impacts on induced investment and regional development. Cost and time saving are both indicators of the impacts of transportation investments on consumers. Impact measures related to resources include measures of environmental damage and measures of energy use. The final major grouping includes indicators which are useful in more than one context, such as land-use and accessibility.

Based on this categorization, the specific impact measures related directly to a particular group of political objectives can be identified. Looking horizontally across rows in Figure 2.5 the various political objectives to which a particular specific impact indicator applies are marked by X's. Group mapping of indicators with objectives is easy to observe, especially in the first three columns where a block-diagonal structure emerges. Impact measures related to business are associated with

economic objectives; those related to growth are associated with long-term economic objectives; and measures relating specifically to consumers or resources match the corresponding objectives.

However, as implied by the bottom row, certain impact measures have broader implications and are related to more than one group of objectives. In particular, land-use, land values and accessibility can be related to long-term economic objectives, social objectives and governmental objectives. The lack of specificity of these broader measures in relation to particular objectives of government could be a drawback in their use to communicate impacts, unless they are carefully presented. On the other hand, if the more general indicators are carefully formulated, they may be especially useful exactly because they can be related to more than one group of objectives. For example, changes in land-use which result from the provision of a major highway link to a relatively undeveloped region can convey information about impacts on regional development, the quality of life of individuals in the region, and the provision of government services in the region.

While the last row of Figure 2.5 displays a group of indicators which are related to more than one group of political objectives, the last column reveals a group of objectives, namely governmental objectives, which are related to more than one group of specific impact measures. Both the provision of government services and the cost of these services are affected by accessibility and land-use. The tax revenue available to support these services is affected by changes in profit and income, by induced investment and by changes in land values.

2.4.3/ The Presentation of Indicators

The above discussion has emphasized the role which indicators of the primary impacts of transportation improvements should play in communicating information to senior management and government decision-makers in support of major decisions. A particular group of indicators called specific impact measures have been identified as being especially useful in expressing impacts in terms most consistent with the direct experience of senior managers and government decision-makers.

Mouaket and Lucey (4) have emphasized that, in order to most effectively convey the intended information, the format in which these indicators are presented must be well thought out. Maps, graphs, or even better, dynamic graphical presentations should be used whenever possible. These presentation mechanisms should be incorporated into the systems which provide impact indicators.

Unless a broad range of specific impact measures is provided, the most sophisticated and well-planned presentation will not fully or comprehensively communicate the impacts of transportation investments to government decision-makers.

The next section provides an example of the proposed role of impact indicators in the communication system within the context of a typical transportation issue.

2.5/ An Example

2.5.1/ Introduction

The preceding discussions are in abstract and general terms with a minimum of reference to actual applications. In order to make that discussion more concrete, an example is presented here. A particular political objective, namely business competitiveness, has been selected for this example, and the use of indicators that relate to the competitiveness issue will be discussed. The general nature of the problem is identified in the first brief section; the second section describes the role of indicators in communicating the impacts of transportation investments on the stated objective.

2.5.2/ The Problem

Urban and regional traffic congestion and its impact on business competitiveness is a major problem faced by the Ontario government and the engineering and transportation branches of local governments. This problem fits readily into the framework developed above. It also permits an assessment, at all four levels of the decision hierarchy identified in Figure 2.1, of the impacts of specified changes in the transportation infrastructure on business competitiveness.

According to the Canadian Automobile Association (1), citing the Metropolitan Toronto Goods Movement Study, transportation charges in 1988 represented roughly 13% of the prices paid for goods by consumers in urban centres. About 40% of this cost was attributed to increased congestion. The two principal reasons cited for the rapid growth in this component of cost are (i) a deteriorating urban transportation infrastructure that raises the costs of fleet maintenance and (ii) congestion induced delays in delivery that raise fleet operating costs. Historical trends [1] suggest that these costs will continue to grow in the future, as more and more vehicles clog the already congested major urban and suburban arteries.

2.5.3/ The Transportation Improvement and the Role of Indicators

Alternative capital investment strategies to alleviate traffic congestion include a widening of the existing facility or construction of a new major artery. For example, the North-South East-West

corridor in Hamilton is proposed to eliminate some of the congestion on the Toronto-Niagara corridor.

In terms of the structure of indicators summarized previously in Figure 2.2, such projects immediately affect the characteristics of the local road system, increasing the capacity, altering the demand patterns, and changing the operating conditions on available roadways. In the case of an entirely new facility, some of the existing traffic will be diverted, for a variety of reasons, from congested parts of the system to the new roadway. A widened facility will handle an existing volume of traffic with greater ease and will likely attract traffic demand from less desirable alternate routes.

In both cases, these changes in roadway system characteristics provide a range of benefits to users which can be represented by the direct-user benefit indicators;

- travel times fall as congestion is reduced. Travel safety increases both with reduced congestion and with the construction of facilities that incorporate the most recent safety design features;

- operating and maintenance costs for households and business firms are accordingly reduced.

The reliability of the local network of roads is also increased by an investment of this type, as drivers, either for business or for pleasure, are able to complete their trips with reduced delay and reductions in the attending uncertainties of congested operation.

On the downside, a more efficient transportation system may attract new users away from other modes of transportation. This substitution in response to intermodal changes in relative transportation costs may partially undermine and limit the indicated gains from congestion reduction.

Turning to the specific impact measures, improvements to the roadway system affect businesses, households, and government, by freeing up time that can be used for productive activity or leisure. A less congested road system means improved profitability; a truck driver can make more deliveries or a business traveller can call on more clients in a given working day, raising the profits of their companies. It also means that there is more certainty within industry of being able to respond to short-term inventory needs (decreased inventory). The consumer gains in the form of more leisure time and greater spending power influenced by lower transportation costs and lower product costs.

This will lead to expanded demands for products and further benefits to business. Delivery of government services is also facilitated.

A major transportation improvement, by enhancing the profitability of established firms, will attract new business to locate along its length. New subdivisions will spring up near the facility, and new home owners will enjoy the many benefits that it provides. The patterns of economic development and land-use are affected by the roadway improvement. Land values will adjust to reflect the new levels of direct-user benefits. The extra leisure time, more relaxed travelling, and improved access to various facilities (schools, hospitals, shopping and recreational centres) signify improvements in the quality of life.

However, offsetting negative effects will almost assuredly result from any new development: including, air pollution and other environmental damage, as well as the creation of extended concrete out of scenic countryside.

The overall social gains from the construction or improvement of these facilities can also be summarized in terms of the global measures of the impacts of these investments (summary impact measures). The flow of future net benefits from a given transportation improvement can be expressed either as a present value figure, or in terms of a benefit-cost ratio.

In short, a transportation investment of the type indicated can be analyzed in terms of all of the indicator measures set out in Figure 2.2. In particular, the specific impact indicators provide information to senior management and political decision-makers which conveys the full range of impacts of the investment and are required for the decision and selection of alternative investments.

2.6/ Conclusions

The above discussions have attempted to identify a need for the Ministry of Transportation to expand the systems which it uses to generate indicators of the impacts of transportation investments. In particular the need to generate what have been termed specific impact measures has been emphasized. The crucial role which these indicators can play in communicating the impacts of transportation investments has been examined in the context of a conceptual model of the decision structure of the Ministry. This role has also been illustrated in a brief example related to typical highway investments.

References:

[1] *CAA Public Policy: 1988-89 Special Edition*, The Canadian Automobile Association, Ottawa, p.3.

[2] Holt, Charles C., "Quantitative Decision Analysis and National Policy: How Can We Bridge the Gap?", *Quantitative Planning of Economic Policy*, Bert G. Hickman, ed., The Brookings Institution, Washington, D.C., 1965, pp. 252-266.

[3] Kornai, Janos, "Models and Policy: The Dialogue Between Model Builder and Planner", *Economy-Wide Models and Development Planning*, Charles R. Blitzer, Peter B. Clark and Lance Taylor, eds., The World Bank and Oxford University Press, Washington, D.C. and New York, 1975, pp. 13-31.

[4] Mouket, Ibrahim M. and James F. Lucey, "Communicating for Results in Managing Pavements in Ontario", *Proceedings of the Second North American Conference on Managing Pavements*, November 2-6, 1987, Toronto, Volume 3, pp. 131-146.

3/ Recommendations for Future Work

This section of the report describes a system capable of generating indicators of the primary impacts of transportation investments. Research needs required to implement this system are also suggested. Both the "indicator" system and the corresponding research needs are organized into a modular structure to allow flexibility in the implementation of the system.

3.1/ Introduction

The preceding section recognized a need for a system which will enable MTO to provide a broad range of indicators of the primary impacts of transportation investments. What is especially important is the need to develop "specific impact measures," since they translate presently available measures of "direct user benefits" (levels-of-service), such as travel time saving, into indicators which are more relevant to senior management within MTO and the political bodies with which they deal (Management Board, Treasury or Cabinet).

As described earlier, the various impact indicators can be arranged in a logical sequence, in which more "basic" indicators provide the input data for the construction of "higher level" indicators. For example, the Ministry may wish to produce indicators of the impact of a transportation improvement such as an improved highway link or an expanded airport on regional development. Initially, indicators of the increased levels-of-service (direct user benefits) would be generated. These indicators would then be used as input data into the calculation of indicators of the increased attractiveness of the region to business and consumers, as well as the associated increased demand for government services and reduced cost of providing these services (specific impact indicators). Subsequently, these indicators would be used as input data into the calculation of indicators of induced investment and changes in land-use, as well as associated increases in regional income and employment (additional specific impact indicators). The resulting set of specific impact indicators describes the impact of the transportation improvement on regional development.

The above example illustrates a sequential process in which indicators at one level (or stage) of the process are translated into indicators at higher levels. The sequential nature of this process allows the indicator system to be organized into "modules" which correspond to stages in the process. In the context of the example, the first module corresponds to existing systems in the Ministry which predict the improved travel times both between the affected region and other regions and within the affected region. The output of this module is used as input data into a module (or set of modules)

which provide indicators of the impacts on business (lower costs and increased market size for both existing and new businesses), consumers (lower transportation costs and better access to employment opportunities and services), and government (lower costs of providing services). The indicators produced by this set of modules would then be used as input data into a regional development module which would generate the impacts on regional development. Figure 3.1 illustrates this process. The indicator system can be organized into a set of interconnecting modules, which together provide indicators appropriate to communication at various levels of the decision-making hierarchy.

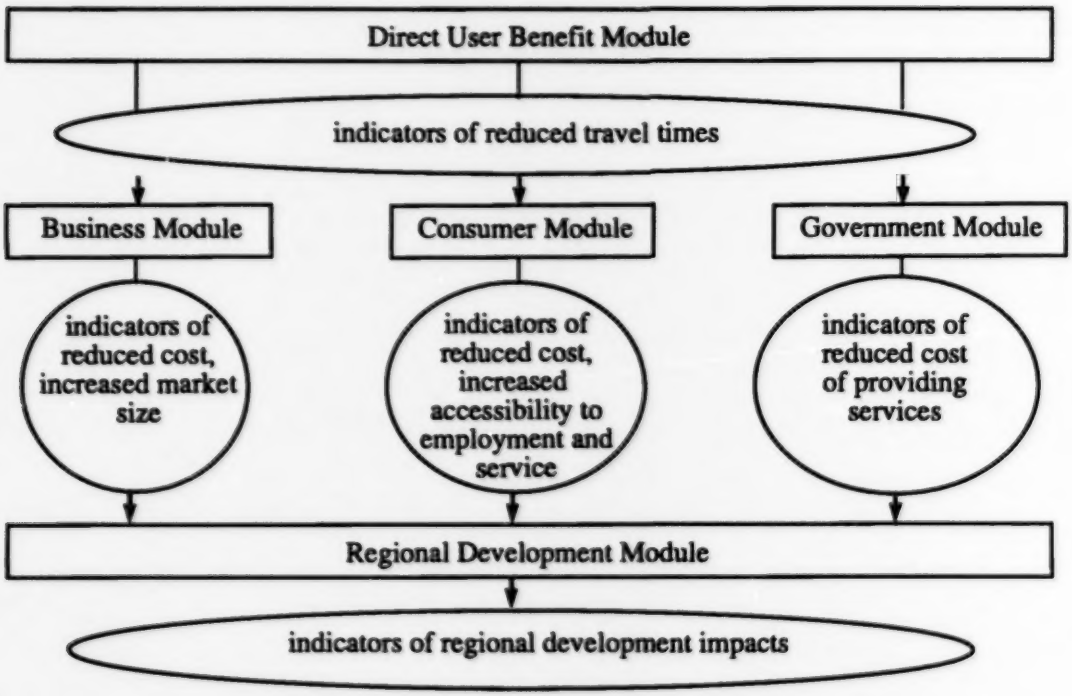
Direct User Benefit Module
indicators of reduced travel times
Business Module
Consumer Module
Government Module
indicators of reduced cost, increased market size
indicators of reduced cost, increased accessibility to employment and service
indicators of reduced cost of providing services
Regional Development Module
indicators of regional development impacts

Figure 3.1/ The modular structure of the indicators system: an example

One approach to developing and implementing the above system of modules would be to follow their logical sequence. If this sequence were followed, the full set of direct user benefit modules would be assembled (including those already in use within the Ministry) and augmented. Subsequently, the specific impact modules would be constructed; and, finally, the modules appropriate to government objectives would be put in place. However, if the research programme were to follow this structure, a substantial amount of work would have to be done (at a cost of approximately 8 person-years of work for the complete system) and a substantial amount of time would have to elapse (at least 3 years) before useful results (higher level indicators which are not available now) would be available

to the Ministry. This would require a commitment of a large amount of research funding and a great amount of time before realizable results become available.

An alternative approach is to start in the first year by developing a system to produce a package of indicators related to one "higher-level" objective, namely regional development. In two subsequent years other indicators in the system, which are related to other "higher-level" objectives, will be developed. Work in the third year of the programme will also include potential revisions to the regional development package, in order to incorporate the results of the work done in the second year.

Regional development is proposed for the initial phase of the programme for several reasons. First, it has been given high priority in recent budgets of the Ontario government. Second, transportation investment has been viewed as one of the major instruments available to achieve this goal. Third, most of the specific impact indicators are related to regional development, so that the results of the first stage of the research programme will illustrate the potential usefulness of a large part of the proposed system of indicators. This last aspect of the emphasis on regional development in the first year of the research programme also has implications for the nature of the first-year results. At this stage, the regional development module will not be able to use the indicators of impacts on business, consumers and government as basic input data, since the modules corresponding to these indicators will not be in place. A "short-cut" approach will be used to provide the necessary input data. Induced investment and changes in land-use are required as inputs to "drive" the regional development module. These inputs will be based on a preliminary version of the induced investment and land-use module, which will be developed as a part of the first-year research programme.

The final product of the research programme will be a system of inter-connecting modules (including those already used in the Ministry to generate some of the direct user benefits, such as improved travel times) which will generate indicators of direct user benefits; use measures of direct user benefits to generate specific impact measures; and, finally, combine specific impact measures into "packages" related to particular political objectives. (The specific impact measures can also be translated directly into summary impact measures which, as discussed above, are more useful for planning processes, such as prioritizing projects, than for communicating impacts. A project to develop summary impact indicator modules could be carried out in a fourth year.) The structure of this system is described schematically in Figure 3.2 and is described in more detail in the following section.

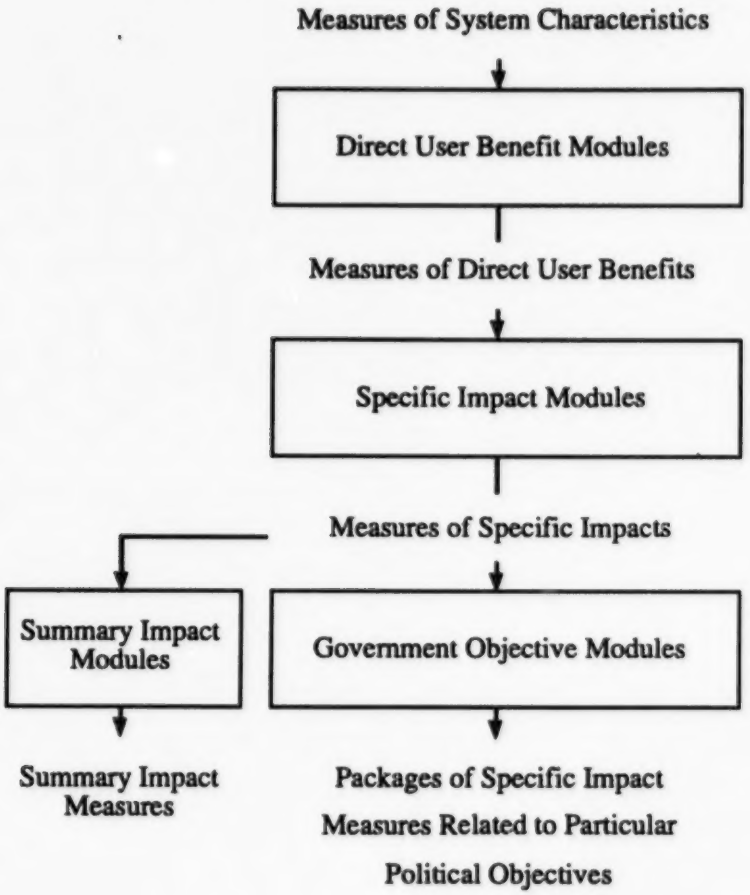
Measures of System Characteristics
Direct User Benefit Modules
Measures of Direct User Benefits
Specific Impact Modules
Measures of Specific Impacts
Summary Impact Modules
Government Objective Modules
Summary Impact Measures
Packages of Specific Impact Measures Related to Particular Political Objectives

Figure 3.2/ The proposed impact indicator system

3.2/ The Proposed Indicator System

The modules which make up the indicator system and which correspond to the various levels of Figure 3.2 are listed in Table 3.1. Although the number of modules listed in Table 3.1 is large, an attempt has been made to show the interconnections between them, together with the indicators produced and the input data required, in Figures 3.3 through 3.5. Each of these figures corresponds to one of the levels in Figure 3.2. These figures are supported by brief descriptions of the modules which are included in each level.

Table 3.1/ Impact indicator modules

I. Direct User Benefits

1.Travel time
2.Safety
3.Vehicle/fleet operating costs
4.Vehicle/fleet maintenance costs

II. Specific Impacts

1.Accessibility
2.Business profit
3.Consumer benefit
4.Government services and government cost-saving
5.Induced investment and land use change
6.Energy use
7.Environmental impacts

III. Government Objectives

1.Regional development
2.Economic growth
3.Quality of life
4.Government services/budget
5.Energy conservation

IV. Summary Impact Measures

1.Land values
2.Net present value

3.2.1/ Direct User Benefit Module

As indicated in Figure 3.1, the role of the direct user benefit modules is to translate system characteristics, such as highway conditions, capacity and potential traffic volume, into direct user benefits. These user benefits include levels of service, such as travel time, travel reliability and safety, as well as the costs associated with these levels of service, such as vehicle or fleet operating and maintenance costs. These modules and the relationships between them are shown in Figure 3.3. In this figure the nature of both the input data and the indicators produced is identified for each

module. Travel time, safety and operating cost modules are already in use within the Ministry, but, at present, knowledge of impacts on vehicle maintenance costs is limited.

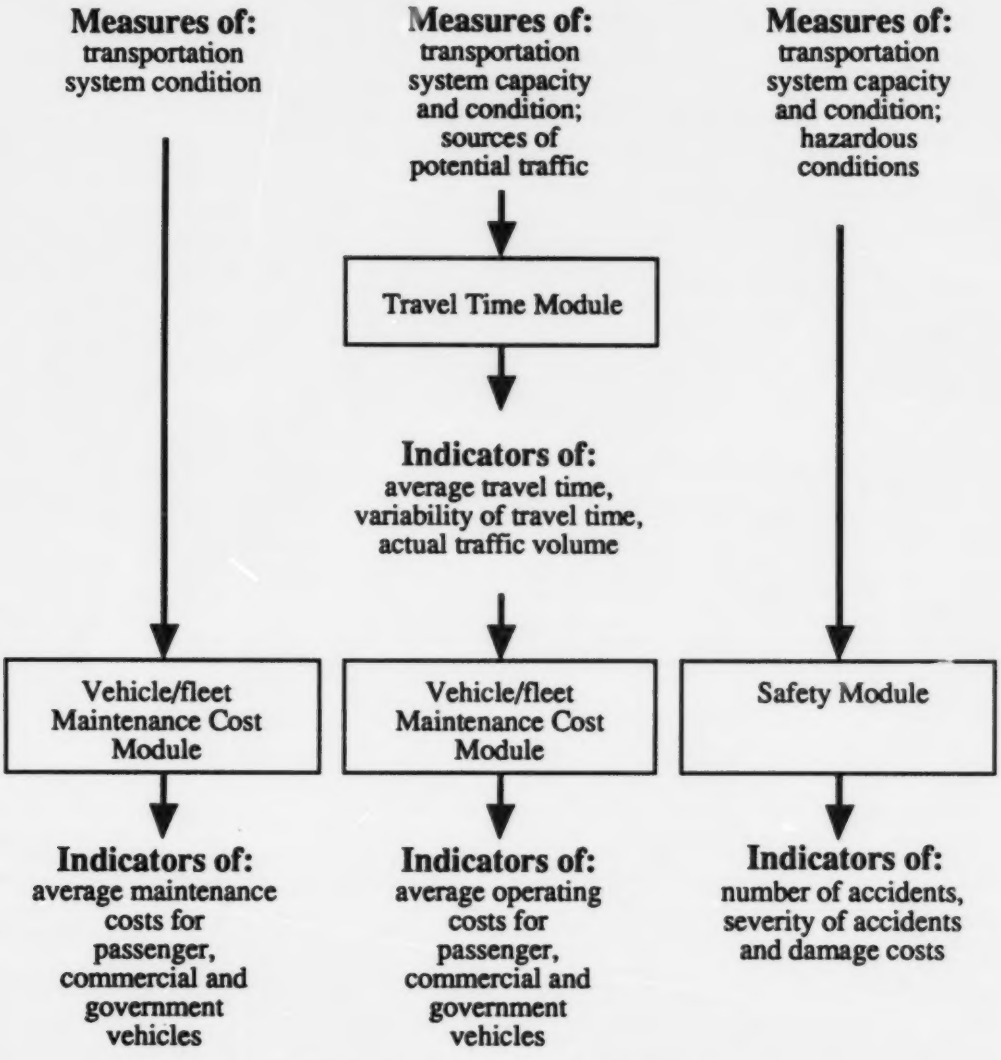
Measures of:
transportation system condition
Measures of:
transportation system capacity and condition; sources of potential traffic
Measures of:
transportation system capacity and condition; hazardous conditions
Travel Time Module
Indicators of:
average travel time, variability of travel time, actual traffic volume
Vehicle/fleet Maintenance Cost Module
Vehicle/fleet Maintenance Cost Module
Safety Module
Indicators of:
average maintenance costs for passenger, commercial and government vehicles
Indicators of:
average operating costs for passenger, commercial and government vehicles
Indicators of:
number of accidents, severity of accidents and damage costs

Figure 3.3/ Direct user benefit modules

3.2.2/ Specific Impact Modules

Each of the direct user benefit modules produces indicators of impact which are of immediate relevance to the users of the transportation infrastructure. The specific impact modules translate these direct user benefits into measures which indicate the significance of the impacts to particular groups of users or to the society as a whole. The relationship among the specific impact modules, together with the input data needed and the indicators produced, is shown in Figure 3.4. The input

data to this set of modules, shown across the top of Figure 3.4, is mainly made up of indicators provided by the direct user benefit modules. Brief descriptions of individual specific impact modules appear below.

Accessibility measures refer to particular locations. They are calculated from input data describing both travel times and the geographic distribution of population and various activities such as employment or government services. These measures are inputs into other specific impact modules, since accessibility affects each of the other specific impacts, either directly or indirectly.

The business profit module will provide indicators of the impacts on business profit of improved reliability (through its impact on inventory systems), reduced transportation costs and increased accessibility (through its impact on market size). The indicators will include both direct impacts on business and indirect effects resulting from lower costs, which may be passed on to other businesses. The consumer benefit module will produce indicators of the overall time- and cost-saving to households, as well as the impact of increased accessibility on employment opportunities, access to government services and social amenities. The module will use travel time and transportation cost savings as inputs, as well as increased accessibility, which are the outputs of other modules.

The government services and cost-saving module will produce indicators of the cost-saving to government which results from transportation improvements. It will also generate indicators of improved access to government services. It will use the same inputs as the business and consumer modules, namely cost and accessibility measures, but will relate these inputs to the provision of government services.

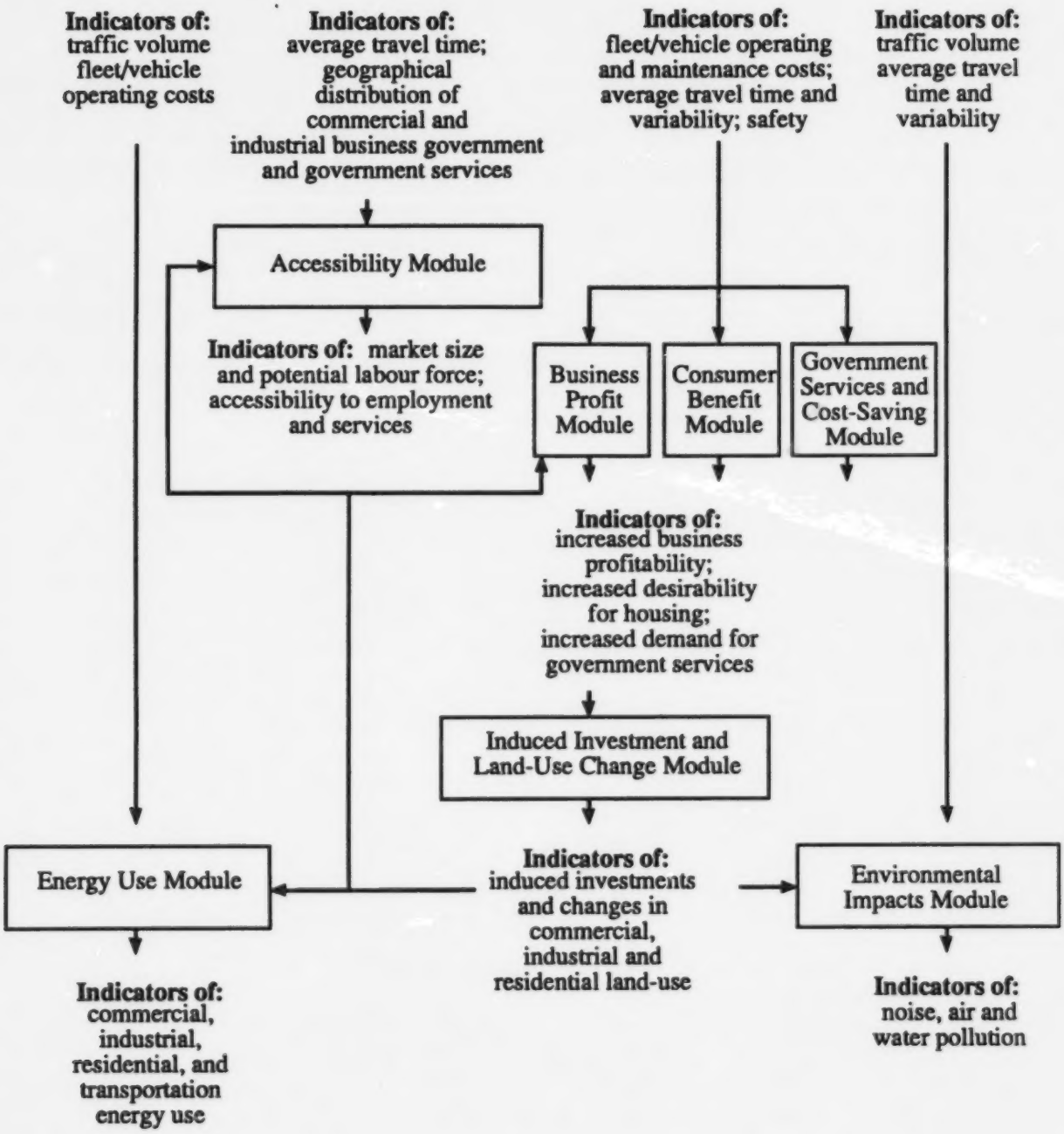
Indicators of: traffic volume fleet/vehicle operating costs
Indicators of: average travel time; geographical distribution of commercial and industrial business government and government services
Indicators of: fleet/vehicle operating and maintenance costs; average travel time and variability; safety
Indicators of: traffic volume average travel time and variability
Accessibility Module
Indicators of: market size and potential labour force; accessibility to employment and services
Business Profit Module
Consumer Benefit Module
Government Services and Cost-Saving Module
Indicators of: increased business profitability; increased desirability for housing; increased demand for government services
Induced Investment and Land-Use Change Module
Energy Use Module
Indicators of: induced investments and changes in commercial, industrial and residential land-use
Environmental Impacts Module
Indicators of: commercial, industrial, residential, and transportation energy use
Indicators of: noise, air and water pollution

Figure 3.4/ The specific impact modules

The induced investment and land-use change module will provide indicators of the degree to which transportation improvements lead to investment in new business and housing as well as associated changes in land use. These effects tend to build cumulatively so that the module will provide indicators of future growth in addition to more immediate effects. For inputs it will use the indicators of impacts on business, consumers and government, together with relevant features of the impacted localities such as travel times to various population centres (which may be summarized in an accessibility measure). Because "growth thresholds" are important for determining these effects, variants of the module will be needed for different locales of rural and urban land-use or different locations relative to major centres.

The energy use module will generate indicators of energy saving which result from transportation improvements. It will be closely linked to the vehicle operating cost module, in order to measure effects on fuel use by both privately-owned and publicly-owned vehicles. It will also use inputs from the induced investment and land use module, in order to incorporate growth effects.

The environmental impacts module will provide indicators of the impacts on the environment, including noise, air and water pollution, which may result from a transportation investment. In addition the module will generate measures of the implicit costs of these impacts, using the hedonic method. This method is described in the proposal on land values included in the Appendix. Input data will include levels of use of the transportation facility such as traffic volumes, as well as travel times and congestion measures. Since growth will affect these factors, inputs from the induced investment and land-use change module will be necessary in order to capture growth effects.

3.2.3/ Government Objective Modules

Each of the specific impact measures can be related to a number of basic government objectives (political objectives). The role of the government objective modules is to relate the indicators of specific impacts to these political objectives. In some cases this will require only a simple packaging of the specific impact indicators, but in others, such as the regional development module, new or extended indicators will be generated. Because the major political objectives tend not to overlap, these modules generally do not require input from each other. The regional development and economic growth modules are an exception because the indicators which they provide represent local and province-wide manifestations of the same development impacts. The government objective modules are represented in Figure 3.5. Input data for these modules consists entirely of indicators provided by the specific impact modules.

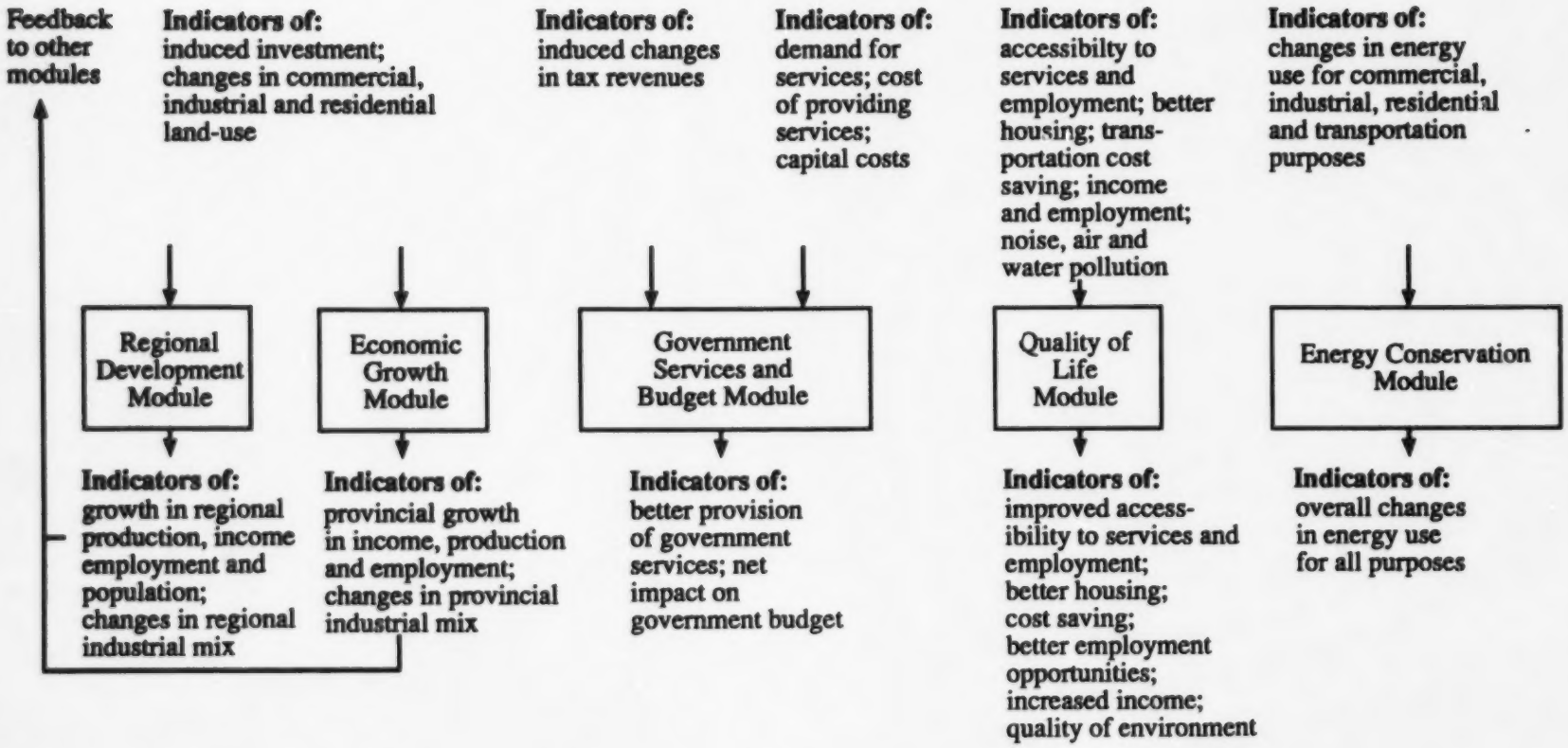
Feedback to other modules
Indicators of: induced investment; changes in commercial, industrial and residential land-use
Indicators of: induced changes in tax revenues
Indicators of: demand for services; cost of providing services; capital costs
Indicators of: accessibilty to services and employment; better housing; transportation cost saving; income and employment; noise, air and water pollution
Indicators of: changes in energy use for commercial, industrial, residential and transportation purposes
Regional Development Module
Economic Growth Module
Government Services and Budget Module
Quality of Life Module
Energy Conservation Module
Indicators of: growth in regional production, income employment and population; changes in regional industrial mix
Indicators of: provincial growth in income, production and employment; changes in provincial industrial mix
Indicators of: better provision of government services; net impact on government budget
Indicators of: improved accessibility to services and employment; better housing; cost saving; better employment opportunities; increased income; quality of environment
Indicators of: overall changes in energy use for all purposes

Figure 3.5/ Government objective modules

The regional development module will use indicators of induced investment and land-use changes as inputs and will provide indicators of the changes in the regional growth profile. This profile will include the growth of production, employment, income and population, as well as changes in the industrial mix or economic base of the region. Because regional development and provincial growth lead to changes in the basic socio-economic structure, they affect all aspects of the impacts of transportation investments, right back to direct user benefits which depend on traffic volume. Thus the indicators of growth which are provided by these modules should be "fed back" to other modules in the system in order to capture growth effects. These effects may be positive, such as increased market size, and reinforced growth; or they may be negative, such as increased congestion, and hindered growth. The entire indicator system should be employed in a recursive manner in order to provide accurate indicators of the regional development and economic growth impacts of transportation investments. This aspect of the regional development module is described in more detail in the next section of the report.

The economic growth module is closely related to the regional development module, but emphasizes impacts on growth for the entire province rather than particular regions.

The government services/budget module collects all indicators which affect either the provision of government services or the government budget. A basic set of indicators is drawn from the government services and government cost-saving module, related to the improved availability of government services and the reduced cost of providing them which result from an improvement to the transportation system. In addition, the government budget may be affected positively by increased taxes resulting from increased production, profit and income (outputs of the regional development and economic growth modules) or negatively by the increased demands for government services which also accompany these changes. The module will produce indicators of the overall impacts of the above effects on the government budget in addition to indicators of the improved provision of government services.

The quality of life module will collect all indicators which are related to the quality of life of Ontario consumers. These indicators are primarily based on the indicators provided by the consumer benefit module. However, it also includes indicators of increased employment opportunities and income which are provided by the induced investment and land use change module and indicators of environmental impacts which come from the environmental impact module.

The energy conservation module is closely linked to the energy use module since decreases in energy use due to transportation improvements are one form of conservation. On the other hand, increased

production and population (as indicated by the regional development and economic growth modules) may lead to increased energy use for transportation and also for residential, industrial and commercial sectors. This module will also provide impact indicators of these changes in regional structures on energy use.

3.2.4/ Summary Impact Modules

As noted above, it is often useful for planning purposes (prioritizing projects) to capture all of the impacts of a project in a single measure, such as a cost-benefit ratio or a net present value. Usually these indicators are less useful for the purpose of communication. However, one summary indicator, namely the change in land value resulting from a transportation improvement, may be useful in this regard. The land value module will provide this indicator. The required input data will be drawn from the accessibility, induced investment and land use change, and environmental impact modules.

3.3/ The Proposed Research Program

Some of the modules described in the previous section are closely related to each other. For example, the regional development and the economic growth modules share a common structure but focus on different aspects of the same set of effects. Several specific impact modules, such as the energy use and government services modules, feed impacts directly into only one political objective module. In these cases the development of more than one module may be done simultaneously. A proposed arrangement of module development into eight research groups is presented in Table 3.2. The regional development project is discussed in detail later in this report because it is being recommended as the initial project in the research programme. The other initiatives are described in a companion report (Indicators of the Impacts of Transportation Improvements).

Table 3.2/ Proposed research program

Proposed Activity	Modules Developed
1. Direct user benefits	Travel-time and reliability Safety Vehicle/fleet operating costs Vehicle/fleet maintenance costs
2. Accessibility impacts	Accessibility
3. Impacts on business profit	Business profit
4. Consumer/Benefit and quality of life project	Consumer Quality of life
5. Government services and government budget	Government services and cost saving Government budget
6. Regional development/induced investment and land-use/economic growth	Regional development Induced investment and land-use change Economic growth
7. Land value/environmental impacts	Land value Environmental impact
8.Energy use/conservation impacts	Energy use Energy conservation

3.3.1 Direct User Benefit

The primary role of this activity is to collect existing systems within the Ministry and organize their outputs in such a way that they can be used as inputs into other modules. In some areas, such as vehicle/fleet maintenance costs, new systems will have to be developed to augment already existing systems.

3.3.2/ Accessibility Impacts

This activity involves development of an accessibility module. The outputs of this module will be indicators of the various dimensions of the accessibility of a particular location, such as accessibility to consumers which determines market size; the accessibilities to employment, government services and to other amenities which affect the demand for housing; and the accessibilities to raw materials and to the potential labour force which influence business profitability. (While development of an accessibility impact module is treated as a separate activity, there is some scope for incorporating its various impacts into other specific impact module development.)

3.3.3/ Business Profit

The major thrust of this activity will be to quantify the effects on business of reduced transportation cost (operating and/or maintenance), improved reliability, and increased market size which may result from a transportation improvement. These effects can be translated into increased profitability in alternative ways. One way is to assume that neither the quantities of products produced nor the selling prices of these products change so that the entire cost saving is captured by business as increased profit. An alternative approach assumes that the quantities of products produced remain unchanged and that the entire cost saving is passed on to purchasers in the form of lower prices. This indicator corresponds to improved "competitiveness" (the ability to provide products at lower prices) of the Ontario economy. This approach can be extended by computing the increased sales of products which would result from the lower prices.

3.3.4/ Consumer Benefits/Quality of Life

In this activity two related modules will be developed; the consumer benefit module and the quality of life module. The consumer benefit module will link the time and cost saving indicators generated in the direct user benefit modules to consumers. In addition, indicators of increased accessibility by consumers to employment, government services and other amenities will be provided. These indicators, together with those related to increased employment opportunities and those related to environmental effects (both from other modules) will be provided as a package by the quality of life module.

3.3.5/ Government Services/Cost and Budget

The government services and cost-saving module will relate the vehicle/fleet operating and maintenance cost saving specifically to the provision of government services, providing indicators of these impacts. In addition, an indicator of increased accessibility to government services will be generated. The government budget module will combine the above effects with indicators of

increased demands for government services as well as increased tax revenues, in order to produce an overall picture of the impacts of a transportation improvement on the Ontario government budget.

3.3.6/ Regional Development/Induced Investment/Economic Growth

This part of the research program will be divided into two phases. In the first phase, the regional development module will be developed, together with a preliminary version of the induced investment and land-use change module. The latter is necessary in order to produce input which "drives" the regional development module. This phase of the project is described in detail later in this report.

In the second phase the induced investment and land-use change module will be revised. This revision will consist of linking this module to the business profitability and consumer benefit modules which will be developed during this phase. The link will consist of relating changes in business profitability at particular locations to decisions to invest at these locations. Careful attention will be paid to "threshold effects" on these decisions. The second phase will also include development of the economic growth module. This module will extend the output of the regional development module to include impacts on growth for the province as a whole.

3.3.7/ Environmental Impact /Land Value

This project will lead to the development of two modules. The first is the environmental impact module, which will provide indicators of impacts on noise, air pollution and other affected aspects of the environment. These relationships are relatively well known and some research has already been done within the Ministry. The second module will provide indicators of increases in land values which result from a transportation improvement. It will combine indicators of the effects of increased accessibility, induced investment and changes in land use together with environmental impact indicators in order to generate an indicator of increased land values.

3.3.8/ Energy Use/Conservation

Similar to other parts of the program, two modules will be developed, one of which is a specific impact module and the other a related government objective module. The energy use module will provide indicators of changes in energy use resulting directly from a transportation improvement. This module will draw its input data from the operating cost module. The second module, the energy conservation module, will combine these direct effects on energy use with indirect effects resulting from induced investment and land use change in order to produce indicators of overall changes in energy use.

3.3.9/ Conclusion

The brief descriptions of the research program presented above are intended to provide just enough information so that the research plan which follows can be understood.

The research program described in the preceding section can be scheduled in a variety of different sequences. The sequence which is proposed here can be modified in both major and minor ways without affecting the final results of the research programme. The sequencing of module development can be changed; modules can be modified or deleted from the program, and new modules can be added. This can be done at the outset of the programme and also, to some degree, during the course of the programme. This flexible approach will allow the Ministry to respond to changes in its needs and also to the perceived usefulness of various indicators which become available at earlier stages in the programme.

3.4/ The Work Plan: Proposed Schedule and Estimated Costs

3.4.1/ The Schedule

The proposed schedule for the research program is shown in Table 3.3., together with the estimated cost, in person-years, of the development of each module or group of modules:

Table 3.3/ Impact indicators work plan: schedule and estimated costs

Year 1 -- (12 months)

1. Regional Development/Induced Investment/Land Use Project (Phase 1) $45,000

Year 2 -- (12 months)

1.	Direct User Benefits	1.1 person-years
2.	Accessibility	0.9 person-years
3.	Business Profit	1.1 person-years
4.	Consumer Benefits/Quality of Life	0.6 person-years
5.	Government Services/Cost/Budget	0.8 person-years

Year 3 -- (12 months)

1.	Economic Growth (including Phase 2 revisions of the regional development/induced investment modules)	0.8 person-years
2.	Land Value/Environmental Impact	0.8 person-years
3.	Energy Use/Conservation	0.6 person-years

As indicated above, the work in the first year should concentrate on developing the regional development module and a preliminary version of the induced investment and land use module. This work should be organized into a single project because of the complementary nature of the two

modules and because of the desire to develop one of the specific impact modules in the first year of the programme.

The estimated cost of this project is $45,000. A full proposal describing this project is presented in the next section.

At the completion of this project the Ministry will be in a position to evaluate the usefulness of the results and decide the extent to which it wishes to proceed with the remainder of the research programme. In the second year of the programme development of 5 modules could be undertaken. These include the direct user benefits module which is essential at this stage of the programme since it provides indicators which drive the rest of the system. The accessibility module is also basic to the system of indicators for the same reason. As noted above, the development of the accessibility module could be linked to the development of several other modules which use accessibility indicators as inputs. The main reason for treating accessibility in a separate project is that the data sources and calculation procedures used to construct accessibility measures are the same, regardless of the nature of the particular indicator being calculated.

The three other modules proposed for development in the second year of the program refer to the specific impacts on business, consumers and government and, for consumers and government, the extension of these and other impacts into associated political objective modules. The development of these modules follows naturally after the direct user benefit and accessibility modules are available.

Because these latter developed modules are fed into others (the political objective modules) they are also scheduled for work in the second year of the research programme. If necessary, the work could be spread over two years, with the first two projects (direct user benefits and accessibility) done first.

Three projects are proposed for the third year of the research programme. The first involves a revision of the regional development and the induced investment modules, in order to link these modules to those developed in the second year of the programme. The first project also includes development of an economic growth module, which is essentially a by-product of the regional development module. The second project combines provision of an environmental impacts module with a land-value module. The land-value module will combine indicators of direct environmental impacts together with indicators of other influences on land values in order to produce an indicator of the land value changes which result from a transportation improvement. The third project also develops two related modules: the energy-use (a specific impact) and energy conservation (a political

objective) modules. The energy conservation module combines the direct energy use implications with indirectly induced energy uses implied by other impacts such as economic growth, in order to provide indicators of the overall impact of a transportation improvement on energy use. Again, there is scope for modifying the set of projects suggested for the third year of the programme or spreading this work out over a longer period of time.

3.4.2/ Costs

The costs of each project listed in Table 3.3 are estimates drawn from the research proposal for the regional development project (phase 1) which appears later in this report (Indicators of the Impacts of Transportation Improvements). As can be seen from these cost estimates, the total cost of the proposed research programme is almost 8 to 10 person-years, spread over a period of at least three years. The largest portion of these costs is apportioned into the second year of the programme, which would require 4 to 5.5 person-years. This cost could be spread over a two-year period if the length of the entire programme was extended to four years.

3.4.3/ Conclusion

The research program which will provide the Ministry with the desired system of primary impact indicators is developed and presented above. A work plan with the cost estimate and possible flexibility of scheduling the program is provided as the decision information. The following section of this report consists of a detailed proposal for the regional development project where a detailed methodology of the proposed research program is described.

4/ Regional Development Impacts of Transportation Investments: A Proposal

In this section we present a proposal for the first project of the research programme outlined in the preceding section. This project develops one group of specific impact measures, namely those associated with impacts of transportation improvements on regional development.

4.1/ Introduction

Recent budget statements of the Ontario government have featured promotion of regional development, economic growth, and improving the competitiveness of the Ontario economy as major objectives. A problem now facing MTO is how to evaluate and communicate the impacts of its various investments in transportation improvements on these objectives. Previous sections of this report have recommended that the Ministry develop a broad range of indicators of the socio-economic impacts of its programmes and use them to communicate the worthiness of its activities to central agencies. In particular, systems should be developed to provide a group of indicators called "specific impact measures," which includes indicators of impacts on regional development.

The main purpose of this proposal is to develop a prototype system capable of generating quantitative indicators of the impacts of transportation infrastructure improvements on regional development and economic growth. This represents the first phase of the research programme outlined in the preceding section. In subsequent phases of the programme the system produced in this first phase will be refined and integrated into other systems which generate indicators of other impacts of transportation investments (e.g., impacts on business competitiveness).

4.2/ Potential Impact of Transportation Improvements on Regional Developments and Economic Growth

4.2.1/ General Impacts

The following presents a review of indicators of the impacts on regional economic development which have been used in earlier studies. In this way the relevant dimensions of regional development and growth are identified as well as the potential impacts of transportation investments on this development. Transportation investments are particularly relevant to regional development as they often result in changes in the relationships of people to commodities and services. These changes affect demands for particular items, and generally lead to spatial rearrangements. The rearrangements occur because, in addition to direct benefits to those who use the new transportation

facilities, there are many advantages that accrue to various types of businesses and parcels of land situated location near the new facilities.

There are many dynamic benefits of transportation investments. Induced investments result from the reorganization of economic facilities and the increased efficiencies that occur following the construction of a major transportation facility such as a highway or an airport. Better accessibility, time and cost savings, and many other related factors inspire new investments; and each such increment in investment has its own ramifications throughout the regional economy. The experiences along Massachusetts Highway 128, the Dallas Expressway, California Freeways, and Highways 400 and 401 or around Pearson airport provide familiar examples of these cumulative impacts.

A highway or other transportation facility tends to reorganize local economic activity, clustering development near them. They aid in directing economic growth to specific locations, thus leading to potential reductions in industrial costs and leading to a more efficient distribution of economic activity over space. Transportation investments are unlike any other investment because transportation affects social and economic, commercial and industrial activities. Any alteration of transportation facilities will tend to affect the spatial ordering of these economic and social activities.

The impacts of highways provide an excellent example of these effects. Highways act as a triggering mechanism. They lead to a better spatial redistribution of resources and production which allows demands to be met more effectively. They generally reduce transport costs, which in turn leads to lower total costs. These lower costs provide incentives which lead to increased output and organization of production in larger and more efficient firms. Highways also lead to lower delivery, warehousing and storage costs. These are particularly significant for small enterprises. Highways generally trigger the growth of highway intensive development such as that found in industrial parks and shopping centres. Both of these arrangements take advantage of the large external economies which are associated with the clustering of activities around transportation facilities.

The importance of transportation facilities can also be seen by examining the consequences of inadequacies in the transportation system. For example, if highway capacity does not meet demands, traffic congestion leads to higher transportation costs for both businesses and consumers and a subsequent reduction in the economic competitiveness through choking off economic growth.

4.2.2/ The Developmental Impacts

One way to outline the developmental impacts of transportation investments is to examine the claims which have been made about them. An examination of the scope of these claims is presented below.

a) *Responding to Economic Opportunities*

New transportation facilities promote regional development to the extent that they allow economic potential to be realized. For example, the free-trade agreement with the U.S. creates a potential for Ontario businesses to expand their sales in nearby U.S. markets. Because land transportation routes to these nearby markets are few (Sarnia, Windsor, the Niagara River crossings and the St. Lawrence River crossings), expansion of these exports will imply increased traffic volumes in well-defined transportation corridors such as the Hamilton-Niagara corridor. Expansion of transportation facilities in these corridors will be necessary if this economic potential is to be realized. This expansion will benefit not only established centres of production in the province but also regions along these corridors. The economy of the Niagara region, for example, is now based primarily on agriculture and tourism. This region may be expected to capture new manufacturing and service activity if the appropriate transportation facilities are provided.

b) *Revitalization of Depressed Areas*

One of the impacts frequently ascribed to transportation investments is their contribution to the revitalization of depressed areas of the economy. The intent is to transform an area that has become blighted or depressed into one that is once again economically sound and self-sufficient. Redevelopment and rehabilitation are the main means of achieving this goal. These processes are supported and stimulated by transportation investments. In order for transportation investments to have the strongest impacts two conditions are necessary. First, the original investment in the facility should have a direct impact on the designated communities. The extent of direct and indirect input-output purchases from the depressed region are critical factors. The second condition pertains to the extent to which the initial transportation investment is capable of inducing private and other public investment in the region. Surely the initial economic base of the region and the existence of a sufficiently large and well qualified labour pool would determine the potential benefits a region can reap from transportation investments.

c) *Rebuilding of Central Cities*

This impact is very similar to the one above. It is limited, however, to a particular type of area. To the extent that the development of one type of area absorbs resources and concentrates activities which could have been used or located elsewhere, the result is a transfer of development. The real question here is to what extent investment represents an increase over and above investment which would have taken place elsewhere.

d) *Stimulation of Private Investment*

Public investments do not necessarily induce private investments. Actually, in the macro-economic literature the assertion is made that public investments "crowd out" private investments. There is strong evidence that investments in transportation have micro-economic effects which lead to increased private investment. Highways in Canada and the U.S. have triggered large highway-intensive investments, particularly in shopping centres, industrial and research parks and warehousing. However, the real question is whether or not this investment is an addition or would have been forthcoming in any case. Evidence from the U.S. seems to suggest that investment around highways has generally been an addition, which has occurred in response to substantial external economies and operational efficiencies created by highway investment.

e) *Strengthening of Peripheral Economies*

This impact will depend on a number of factors that are external to the transportation investment. First, the extent of benefits to a particular local economy will depend on its initial economic and export base, on the size of the project, and the extent to which the project would enhance the comparative advantage of the local economy vis-a-vis other areas of the economy. Secondly, this impact depends on the nature of the investment project and the extent to which already existing resources would be called upon to meet the requirements of the investment. In a peripheral economy considerations of accessibility may dominate other economic expansion initiatives. Accessibility increases the size of the market and reduces the cost of transporting output and inputs, as well as reducing the spatial separation of workers from more attractive jobs.

f) *Increasing Local Employment*

The growth in service activities which tend to cluster around transportation facilities are labour intensive and, as a result, tend to stimulate local employment. The same is true of the warehousing and light manufacturing activities which tend to be developed subsequent to the service activities. However, an investment in transportation will not increase employment and

realize the full potential of the local economy unless the local labour force has skills applicable to the contemplated projects or workers with the required skills can be attracted to the region.

g) *Expanding the Local Tax Base*

A transportation investment can expand the local tax base in two distinct ways. First, there is the increase in the level of economic activity both during the construction phase and subsequently due to developmental impacts. The associated increases in wages and incomes and in the purchases of goods and services may provide the local economy with increased tax revenues if it has access to tax revenues based on these sources or can obtain access to these revenues from higher levels of government. Secondly, and perhaps more importantly, there will be increases in the value of local properties as primary transportation benefits are capitalized into the land and property values in the local area. These increased property values will provide the basis for larger local tax revenues.

The above discussion has presented a range of arguments which have been used to describe the various developmental impacts of transportation investments. The magnitude of these impacts must be evaluated in order to identify the regional development impacts of transportation investments. This evaluation will be most meaningful if these impacts can be measured by accurate quantifiable indicators. The purpose of this proposal is to develop the prototype of a system which will enable MTO to provide accurate quantitative indicators of the above developmental impacts.

4.3/ Methodology

4.3.1/ Background and General Approach

Regional development and growth involves changes in economic structure, based on both new investments and the relocation of existing activities. The usual input-output based impact model has a static framework which cannot capture these effects. For example, TRIM measures the impacts of the construction phase of a transportation investment on income, employment and other economic variables. A static model such as the one used in TRIM is perfectly suited to measure these impacts. The impacts are, however, transitory. On the other hand, impacts on regional development and growth are not transitory but correspond to permanent changes in the location of activities and spatial distribution of demands. These impacts have the effect of altering existing linkage patterns in the economy while also establishing new ones. Only a dynamic model can capture these changes.

The Lowry model (1) has been the basis for most descriptions of the links between transportation investment and land use (see Bly and Webster (2) for a summary of recent models). Although its implementation often uses the gravity approach, the core of the Lowry model is a cycle in which new employment opportunities in manufacturing or other basic industries lead to increased population and new demands for housing and services, which in turn lead to more employment increases. While this cycle may be appropriate to urban areas, in non-urban or relatively undeveloped regions the Lowry cycle appears to be reversed - the initial impacts are often on service employment that is associated with increased traffic flows (see for example Eyerly, Twark, and Downing (3)). In subsequent stages, small-scale manufacturing may be attracted with large-scale manufacturing appearing only at a later stage. These stages are not part of a smooth growth process; rather, growth often proceeds in spurts with the next stage appearing only after threshold levels of available services, demand and manpower are reached (see Moon (4)).

The stages and links in a Lowry type model may be captured in a number of ways. Although the usual implementation features gravity linkages, one widely used system (the MEP model summarized in Bly and Webster (2)) has used input-output structures to model these links. It is propose that the same basic approach be used for this project. Because regionalized input-output systems for Ontario are well developed, the input-output approach is recommended.

The ideal modelling approach would build upward from the basic impacts of transportation investments on travel time. These would be translated into impacts on accessibility and transport costs. The impact of lower transport costs and greater accessibility on business profitability, the demand for housing and government services would then be determined. Subsequently, these impacts would determine changes in the location of businesses, housing and population, and government services. At this stage of the research, developmental thresholds would be identified and quantified. The later stages would be described using a dynamic input-output structure to capture the Lowry-type linkages. The resulting model would be capable of simulating the regional development process, which could trace out all of the development impacts of new transportation investments or improvements in the transportation system, as described in section 3.

This project represents the initial stage of the construction of the above ideal system. In this first stage, the linkage from transportation investments to initial changes in the location of business, housing and population, and government services, will not be fully developed. Instead, attention will be primarily focused on development of the regional growth model. The regional model to be developed in this project will be a prototype of the final model. Response of MTO to this prototype will guide future research leading to a final model. However, in order to provide the inputs required

to drive this regional growth model, a preliminary version of the land-use change and induced investment model will be developed as a part of the project. The overall structure of the resulting system is shown in Figure 4.1.

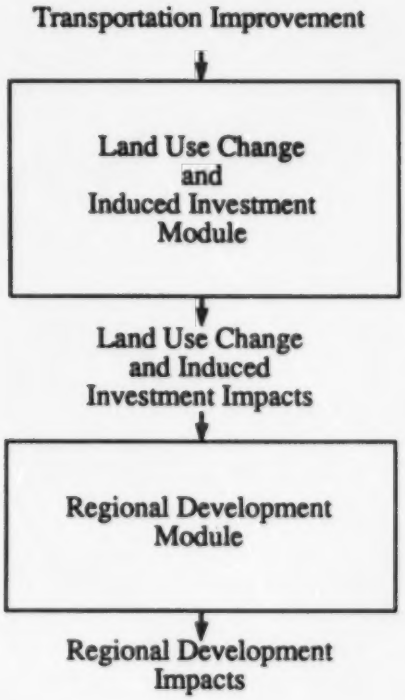

Figure 4.1/ The regional development indicator system

4.3.2/ The Regional Development and Growth Model

The regional input-output structure will be based on the "balanced regional model," which was first proposed and later used by Leontief (5,6). This model will be embedded into a dynamic recursive structure in which initial induced investment leads to increases in production; these increases in production lead to increases in employment and income; and these increases lead to further induced investments.

The mathematical structure of the model can be simplified (the full structure is very complex) by the following sets of equations:

1) The first set of equations link transportation improvements to land use changes. This set of equations will be based on econometric methods as used, for example, by Buffington, Chui and Memmott (7). In these equations, features of the local region and surrounding regions,

such as population and production, will help determine the impact of the transportation improvement. The initial versions of these equations will be calibrated using several Ontario cases.

2) The second set of equations link land use changes to induced investments in housing, commercial and industrial developments and increased consumption and provision of government services in the affected region or regions. These equations will initially be based on simple conversion factors derived from relevant Ontario data.

3) The third set of equations is the regional input-output model which will calculate the increases in production, employment and income associated with the induced investments and other changes computed in the equations of set 2. These equations will be based on 1984 Ontario data, the most recent currently available.

4) The fourth set of equations will convert employment changes into population changes which, together with sales and income changes from equations 3, will subsequently be fed back into equation set 1 to start a subsequent round of calculations of additional developmental effects. These "recursive" calculations will provide time profiles of the indicators of developmental impacts.

4.3.3/ Research Plans and Required Data

Two types of data will be required for the project, corresponding to the two major research activities. First, a data base will be needed to allow an estimation of econometric equations relating land-use changes to transportation investments. It would be possible to "borrow" results from similar equations estimated in previous studies using U.S. data; however, we believe that even at this prototype stage it is desirable to make a preliminary calibration of these equations using Ontario data. This is important in order to link the model to data and data bases currently available for Ontario. In this preliminary work the impacts of two or three major transportation investments, such as the construction of Highways 400 or 404, will be chosen as a basis for calibration. The particular investments will be selected in consultation with MTO. Data describing the transportation investment will be obtained from MTO. Data describing resulting changes in land-use and relevant local demographic and economic characteristics will be obtained from several sources. MTO's inventory of municipal data may be helpful. Other Ontario government data bases, such as the "SHARK" data base belonging to the Ministry of Treasury and Economics, may also be useful. In addition, some data is available from Statistics Canada from both the Census and the published data on sub-provincial areas. Finally, it will be necessary to gather information on changes in land-use from

municipal and regional planning departments. The econometric equations will be estimated separately for each case using time services data and also for all cases together using pooled data. It must be emphasized that the results of this activity will be very preliminary and that future work will be necessary in order to refine this element of the system. This preliminary work is necessary, however, in order to provide inputs to drive the regional impact model.

The second major component of required data is that necessary for the regional impact model. This model will be based on input-output data for Ontario which is available from Statistics Canada. Data for 1984 (the most recent) is now available. Additional data describing the distribution of sales of each input-output industry by county within Ontario will be necessary in order to implement the regional structure of the model. This data will have to be obtained from various data-bases within the Ontario government, as well as from Statistics Canada. Detailed data on the commodity composition of investment expenditures by industry and capital stock by industry in Ontario are available from Statistics Canada. In addition, data on employment by industry in Ontario will be obtained either from Statistics Canada or from the Ontario Ministry of Labour. This data is necessary in order to incorporate the induced investment and population change effects into the model.

4.3.4/ Results of the Project

The project will result in a prototype computerized regional impact model. This model will require a description of the nature of the transportation investment and initial demographic and economic characteristics of the affected region or regions as input data. The outputs will be time profiles of impact on sales, employment and income by industry and region, as well as population by region.

4.4/ Schedule of Work

The initial work will be divided into two independent parts, which will be carried out simultaneously. Subsequently, the two resulting portions of the system will be integrated and tested. The following tasks will be performed:

1) development of the regional input-output model
   i) data collection - 2-person months
   ii) development of computerized model - 6-person months

2) development of land use change and induced investment model
   i) data collection - 4-person months
   ii) econometric estimation - 4-person months

3) integration of the two models and system testing - 2-person months

4.5/ Conclusion

The proposal which has been presented in this section is intended to demonstrate to MTO both the advantages of providing a broader range of indicators of the impacts of transportation investments and the feasibility of doing so. It will provide a prototype of the desired system. This prototype will provide MTO with a decision-management tool and information to guide it in planning future development.

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5/ Conclusions and Recommendations

5.1/ The Problem

Communication of the Ministry's activities and their effects on Ontario's social and economical development is a major responsibility of the Ministry as identified in Strategic Directives. Earlier work by Moaket and Lucey (1) identified two barriers to this communication objective. First, the absence of modules transferring the main concerns of technical staff and technical decisions into concerns of senior administrators within the Ministry and government decision-makers outside the Ministry dealing with broad socio-economic objectives, and secondly the lack of common language between technical staff and government decision-makers.

The Ministry can help alleviate both of these difficulties by translating the concerns and language of technical staff into the broad socio-economic concerns and language of its government decision-makers.

5.2/ The Potential Role of Specific Impact Indicators

To analyze this problem the communication channels between 4 levels of the idealized internal structure were identified: governmental decision-makers in central agencies, senior management, technical staff and operational personnel within the Ministry. Associated with these levels are three communications interfaces between adjacent levels within the hierarchy. Because the concerns and language at the operations-technical staff interface are technical and those at the senior management-government interface are socio-economic, the technical staff-senior management interface is identified as crucial to the translation of technical concerns and language into the socio-economic concerns and language which are most relevant to central agencies.

The TRIM system currently in use in the Ministry generates indicators of the economic impacts of transportation investments improves the ability of the Ministry to communicate the impacts of its activities to central agencies. However, TRIM only provides indicators of the economic impacts of spending on construction, equipment or maintenance (termed secondary impacts). It does not provide indicators of the socio-economic impacts derived from the use of new, improved or better-maintained transportation facilities (termed primary impacts).

Primary impact indicators can be classified into four groups. First are indicators of basic transportation system characteristics, such as highway capacities or condition. Second are indicators of direct user benefits, such as travel times and operating costs. Third are indicators of specific impacts on particular groups within Ontario, such as impacts on business competitiveness or regional development. Fourth are indicators which attempt to capture the summary impact on all groups within Ontario, such as a net present value or a benefit-cost ratio. These groups of indicators are arranged in a natural sequence in the sense that each group provides the basic inputs for generation of the next group. For example, highway capacity (a system characteristic) is one of the inputs required to calculate average travel time and operating cost (direct user benefits). These, in turn, are factors which affect business competitiveness (a specific impact). Business competitiveness is one element of the contribution to net present value (a summary impact indicator). This natural sequence of groups of indicators can be associated with the hierarchical structure of the decision and communication system. The first two groups (system characteristics and direct user benefits) are technical measures which are used at the operational and staff levels. The third and fourth groups (specific and summary impact indicators) describe socio-economic impacts and thus are relevant at the senior management and government levels. Of these two groups, specific impact indicators are identified as the most useful for communicating the impacts of transportation investments to senior management and central agencies because these indicators relate easily to identified impacts on identified groups in Ontario, such as profits of business or growth of a particular region. These indicators provide a useful link between the technical concerns and language of staff and the broad socio-economic concerns of senior management and government decision-makers.

The ability of the Ministry to communicate the impacts of its investments to central agencies could be substantially improved by expanding the range of available specific impact indicators. This report recommends that the Ministry embark on a research programme aimed at expanding its ability to generate indicators of specific primary impacts of transportation investments.

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